REMARKS
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We all thank our lucky stars for the privilege of spending our lives as scientists. That shared sense is one of the things that makes our scientific community, with all its tensions and warts, such a remarkable phenomenon. And to receive an honor from the community, is deeply gratifying, and I thank you.

Being a local, I also want to welcome you to Washington. Arriving in this city must elicit contradictory feelings. As those of us who live here know, it is beautiful. Yet there are pockets that are ugly both physically and spiritually. These days, there is a spirit for positive change that has not been sensed for many years; but there is also a good deal of justifiable skepticism about just how much promise is imbedded in that spirit. For us, as scientists, we are reminded in this city that although science is remarkably exciting and productive, the policy questions surrounding science are a mixed bag, engendering optimism and pessimism in about equal measure. Who could help being optimistic about the appointments of Harold Varmus at the NIH and Neal Lane at the NSF? Both of them understand, in their bones, the point of supporting fundamental research and the folly of asking science to accomplish what it is not yet able to do. They will represent us well. Who could help but be optimistic these last few days, watching the astronauts repair the

Hubble Telescope? The nation and NASA made this extraordinary effort for only one purpose: to do better pure science; little if any practical application or improvement in economic competitiveness will follow from a better measure of the Hubble Constant. And, in the last months, Congressman George Brown has really been able to stem the abuse by academic institutions and politicians, of pork-barrel funding of facilities while the Seante Appropriations Committee stated that a large proportion of the NSF budget should be set aside for academic infrastructure.

On the other side, though, have been a whole range of troubling statements about science and its failure to contribute to national welfare or to solve national and international economic and social problems.. Many of these statements have emanated from the same Congressman Brown. And they are expressed most straightforwardly in that same Senate Appropriations Committee, chaired by Senator Barbara Mikulski, a report that accompanied its recent decisions on the National Science Foundation budget. It is that statement that calls for quantifiable performance milestones and for at least 60 percent of the NSF research funds to be applied to what are called 'strategic' projects that is, applied research. Just to make sure the message is clear, te report says that the NSF's plan should be "one that does not shroud 'curiosity-driven' research under the rubric of strategic activities.

Most recently, in the fall 1993 issue of the American Scholar, Freeman Dyson took up some of these questions and in a way that has made a lot of people angry, as he himself reports. Professor Dyson is to some an almost mythical figure who, though he may not always be right, is, always, provocative and original. He forces us to look at issues inside-out and upside down and he sees implications that elude most of us. These are the methods of great science; they can lead to new insights or to blind alleys. Either way, it is worth thinking about such ideas.

Professor Dyson reminds us that science and ensuing technological developments produce social change and further, that such change inevitably means that some people will be better off and some worse off. He goes on to point out that up until World War I, young people generally benefited from the changes wrought by science, while older people were the losers. This he says, was tolerable, because parents knew that their children's lives would be be better than their own. The technologies introduced in World War I, however, meant that older people were the winners and the young, who fought and were killed, the losers; this, says Dyson, engendered hostility toward science in England, an hostility he knew growing up there between the two World Wars. For similar reasons, he says, the war in Vietnam, left in the U.S. a negative reaction against science among young people. The peaceful years of the late 70s and 80s brought much innovation, but again older people were largely the beneficiaries and there is no denying what most of us know, from experiences with our own, middle class children, that they will be

lucky if, as adults, they can maintain the standard of living in which they were raised. Others can anticipate much less; there is an increasing disparity between the lives of the poor and the well off in our country; we need only compare the health care or the educations available to these two groups to be convinced.

After this analysis, Professor Dyson comes to the tough part, the part that has made so many people angry. And here, I will quote a few sentences. "This state of affairs is ethically intolerable, and if we scientists are honest, we must accept a big share of the responsibility for allowing it to happen.....Why put responsibility upon the scientific community for the decline of urban society and public morality in the US? Of course, we are not alone responsible. But we are more responsible than most of us are willing to admit". What follows this quote in Dyson's article is a list of what he sees as scientists' contributions to these inequities. The list includes an output of more toys for the rich than necessities for the poor; the growth of university and government laboratories as a welfare program for the middle class while the technical innovations developed in those laboratories take jobs away from the poor; a widening split between the technically competent computer-owning rich and the computerless, technically illiterate poor. And so on. Dyson believes that we have not yet heard the full wrath of the disadvantaged public and its representatives. And he echoes Congressman Brown and Senator Mikulski, saying, and again, I quote, "To forestall such attacks, whether or not we feel guilt for the sins of society, the scientific community should invest heavily in projects

that benefit all segments of our population." Significantly, however, he does not echo the Congress in the projects he proposes. He does not suggest that we can, directly, influence the economy of our nation by concentrating our efforts on applied science. But he does urge a major commitment, by the scientific community, to the education of the nation's children....all of them, but primarily those who have been left behind. Here, the echoes are with Bruce Alberts, the new president of the National Academy of Sciences.

Professor Albert's views are plainly expressed in his first letter to the Academy members since taking office. He says "that we can use the scientific and engineering community much more effectively to facilitate revolutionary changes in science education that could revitalize our nation's schools. This means a different approach than visiting a classroom and giving a lecture; we need to use scientists to support our outstanding teachers and help them achieve the kind of changes that would make a major difference for the education of young people". Those of you who know Bruce Alberts recognize in these statements that he means business. Professor Alberts was himself instrumental in beginning such a revolution in the San Francisco schools in the last few years. In coming to Washington and to the Academy, he has an opportunity to inspire and galvanize the scientific community to follow suit. He does not mean more committees and more reports. He means to convince all of us to roll up our sleeves and join up.

One of the questions that reporters like to ask scientists is how they first became interested in science. Remarkably, most scientists seem to give the same answer. A teacher. In high school, sometimes even earlier. Often, the scientist goes on to describe this teacher in great detail, someone they may have last seen thirty or forty years earlier....They remember what the teacher looked like, what it was that the teacher did or said that lit a fire in the young student's mind. Some of you probably have such recollections.

Andre Sakharov, in his memoirs, tells us that his first science teacher was his father who was a physicist. The elder Sakharov taught physics in school, and in institutions that trained teachers and he was a writer of popular books and simple texts about physics. The titles of these books suggest that the senior Sakharov knew several things that a lot of us, and a lot of those now teaching science in US schools have forgotten; namely, that science is the more meaningful the more it deals with the familiar world and that the concepts of science arise from the observation of or experimentation with, **things**...real things, be they living plants or animals or rocks or stars or molecules. One of the titles is The Struggle for Light, which describes the physics and history of lighting devices. Another is entitled The Physics of the Tramcar, another Experiments with a Lightbulb.

I was particularly delighted to read this about Sakharov's father because the titles of these books reminded me of the ways that science is taught at First Light. First Light is a free, Saturday,

informal science program for elementary school children.. It is sponsored by the Carnegie Institution of Washington, and held at the Institution's Administration Building some blocks east of here. Most of the children are from the neighborhood, that is, they are what we call inner city children, mainly poor, mainly African American and Latino.

I started First Light five years ago, when I became convinced that the most effective way to improve science education, particularly among inner city children, is to start with elementary school students. The program is publicized in nearby schools, and children are invited to join on a first come first serve basis. We raise the money for this from local and national private foundations. Many private foundations as well as the National Science Foundation, are, these days, interested in education projects and it has turned out to be easier to raise money for First Light than for research, only partly because it takes less money than research. First Light has its own laboratory, shaped from an old shipping room. The children spend the morning in the lab and, after lunch, make trips to various places of interest around Washington. According to their parents, it is easier to get the children out of bed on Saturday than on any other day. According to their teachers, their attention spans and school work has improved. According to me, they ask the most pointed and difficult questions about the natural world that I can imagine. Some of the children have been coming steadily for four years. Their vocabularies are rich, their questions are bold, and their

understanding of scientific ideas is exciting; and none of it has been learned from books.

The intelligence behind First Light is Charles James, the person who designs the curriculum and is the primary teacher. Mr. James' full time job is science teaching in a private elementary school in Washington, and we know that his methods are as effective with upper middle class, privileged kids as they are with the inner city children. A trip to a sea food market is a fine way to teach comparative morphology, particularly when it ends up by purchasing specimens and dissecting them sitting on the grass by the banks of the Potomac, with the river habitat nearby to observe. A trip to a building site complements mornings spent considering the properties of materials. Sitting on the table when the children arrive in the morning, they may find a large beaker of water containing a can of coke, sunk to the bottom, and a can of diet coke floating at the surface; the morning is spent trying to figure out why, an opportunity to learn about buoyancy, and to practice skills for weighing and measuring volumes. One of Mr. James' greatest lessons is the dissection of a disposable diaper, which turns out to be a very hi-tech device. This project involves considering several different kinds of glues and materials, including what it is that absorbs almost a liter of water; the morning usually winds up with a discussion of how the water molecules fit into the space between the atoms comprising the absorbent.

Most of the elementary schools in the U.S. are quite different from First Light and also from the schools that I and most of you attended. Those of us who were educated during the Great Depression or the years of World War II had one of the few advantages those years brought. Many dedicated highly educated people who, in our more affluent era, would have been professionals and professors, found themselves instead teaching children in school. In the earlier grades, they introduced their students to the natural world through the study of natural history; their own educations prepared them to do so.. Today's elementary school teachers, many of whom are superb and dedicated teachers, are, as a group, poorly prepared to introduce their students to natural history, or to the science and technology that is now so central to their lives. This is no fault of the teachers; it is the fault of the system that educated them and the school boards, systems, citizenry and parents who have permitted the situation to develop and be maintained. It is also our fault.

In the earlier time, those who might have been scientists taught science in high schools. Like the elder Sakharov, they were respected as professionals, as scientists. Today, those teaching science in high school are often untrained or poorly trained for that job. They are asked to teach things they don't understand, from dense and boring text books, and their main goals, set by others, is to prepare their students for examinations which test little but their capability for memorization. A recent Academy study on the teaching of biology points out that high school students learn more

new words in their biology courses than in first year French. And teachers of undergraduate biology and mathematics to whom I have spoken have the same complaint, even about those who pass advance placement tests; they know a lot of words and equations, but they don't know what any of it means. In this context, I agree with Freeman Dyson; the situation is the responsibility of the scientific community. Our inattention helped cause it. It is up to us to help fix it.

The challenge can be divided up in several ways. First, training elementary school teachers requires one approach; these teachers cannot be specialists yet they can become comfortable enough with an experiential, hands-on approach to science if they are appropriately trained and supplied with materials designed to address specific scientific questions. In those places in the country where this has been tried, students, teachers and parents are excited about what they are doing. One challenge is to retrain present teachers. Another is to restructure the education of those training to be teachers. This same division of the challenge applies to high school teachers; current teachers want and need help and training of new teachers can be improved. One of the outcomes should be to enhance the teachers' identity with science as a profession. In this, there are important contributions that the can be made by the scientific societies. And, individual scientists can contribute by encouraging and respecting those of their undergraduate students who aspire to careers as high school science teachers.

All of these challenges define projects that you and the members of your societies can engage. They are not easy. There are political problems to be addressed, in the community and in the university. These are made more complex these days by the pressure for multicultural education and Afrocentric education. University people are familiar with these issues in the university context. In K-12 education, many of the cultures now contributing to American life are clamoring for inclusion, and rightly so. Science does not, however, have deep roots in some of these cultures and the importance of science and technology for responsible citizenship and for ensuring access to rewarding employment is not always understood. Moreover, the distrust of science that Dyson refers to is another hurdle to be considered.

These are difficult challenges, but there is also help available. All over the country scientists are beginning to engage these issues. Their experience can help. When we decided to enlarge the Carnegie Institution's efforts by undertaking to train substantial numbers of elementary school teachers here in Washington, something we will launch this coming summer with substantial support from the National Science Foundation, we discovered deep resources. Bruce Alberts and his colleagues in San Francisco shared their experiences with us. Leon Lederman, seriously engaged in teacher training in Chicago helped. The National Academy of Sciences and the AAAS and the National Science Teachers Association all have serious and extensive efforts well under way to define what children should learn, how to structure curricula, what the standards should be, and

how to assess the effectiveness of efforts. Simple kits, that can be recycled, are available from several agencies including the Lawrence Hall of Science and the National Science Resource Center which is a joint venture of the Academy and the Smithsonian Institution; elementary school teacher training can focus on these kits and the kinds of questions that children are likely to raise during the experiments. Most important of all, is to come to such projects in the spirit of a joint, cooperative venture. Success depends on listening carefully to the advice and concerns of teachers, principals, and parents. We may know about science, but most of us have precious little idea of how to teach it to young children, or even high school students. The major San Francisco earthquake occurred during the first months of First Light; it was easy to recruit a very eager young earth scientist from a Carnegie department to come downtown and talk to the children about earthquakes. But it didn't work. With no training in how to talk to young children, the young scientist lost his audience within a minute, in spite of his evident enthusiasm. Mr. James came to the rescue; in another minute we knew that some of the children who were immigrants from Central America had themselves memories of experiencing earthquakes. From their descriptions and after a few well chosen questions from Mr. James, the children were considering what goes on under the surface of the planet. By the end of the hour they were comfortable with a rather sophisticated view of the structure of earth.

Perhaps it is not very gracious to thank you for this award by throwing out such challenges. But, if we are to sustain what we hold

so precious, the extraordinary accomplishments of modern American science, we must take seriously the demands of the citizenry that supports us so very well. Those demands will not be quieted by self-serving statements about the importance of fundamental research, regardless of how true the statements are. But they can be quieted by a real response, by meaningful contributions to what ails our nation. Science education is the right contribution for us; it is something we know how to do; and if we succeed, it will be to the advantage of science as well as the nation